Nanoparticle-Mediated Epitaxial Assembly of Colloidal Crystals

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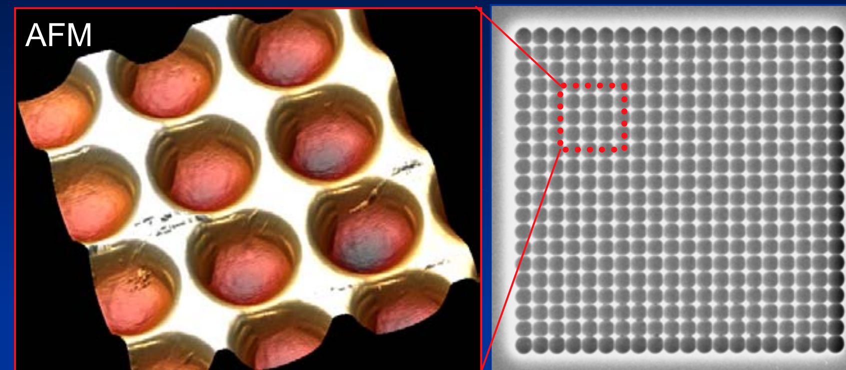
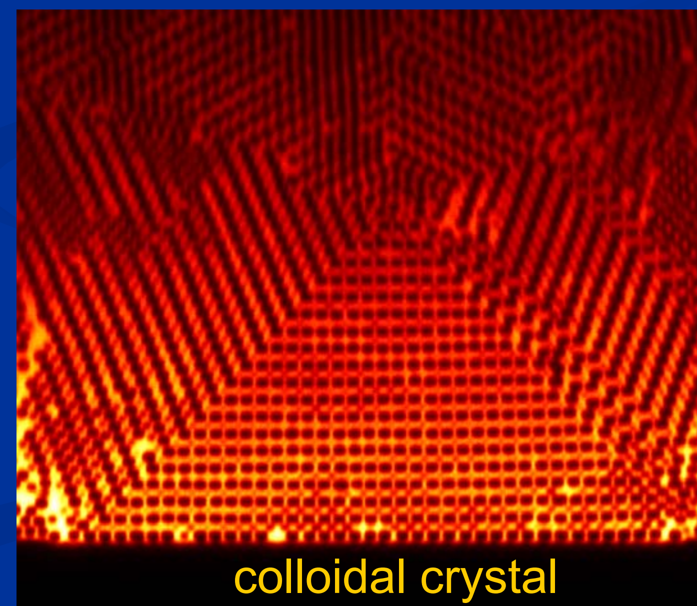
3-D colloidal crystals have been assembled from binary mixtures of colloidal microspheres and highly charged nanoparticles on epitaxially patterned substrates. Confocal microscopy was used to directly observe their structural evolution during the assembly process. After microsphere settling, the nanoparticle solution surrounding the colloidal crystal was gelled, which enabled drying with minimal microsphere rearrangement. We generated full 3-D reconstructions of their structure including defects as a function of initial suspension composition and pitch of the patterned features. Through proper control over these important parameters, 3-D colloidal crystals were created with low defect densities suitable for use as templates for photonic crystals and photonic band gap materials.



FIB-patterned substrate



W. Lee, A. Chan, J.A. Lewis, and P.V. Braun, *Langmuir* 20, 5262-70 (2004). (*cover article*)

The performance of 3-D photonic band gap materials are strongly dependent on their structure (including defects). Photonic materials control the flow of light in an analogous way that semiconducting materials control the flow of electronic carriers. Hence, band gap (or defect) engineering is important in both classes of materials. Normally, random defects, such as domain boundaries and cracks, are introduced during the assembly and drying of colloidal crystals, which severely degrade their targeted optical properties. Here, we report for the first time a new directed assembly route that allows us to create crack-free, single domain colloidal crystals of precise crystallographic orientation with low defect density.

Ultimately, our efforts have the potential to lead to new optical devices for chemical/biological sensing, opto-electronics, optical computing, and telecommunication networks.

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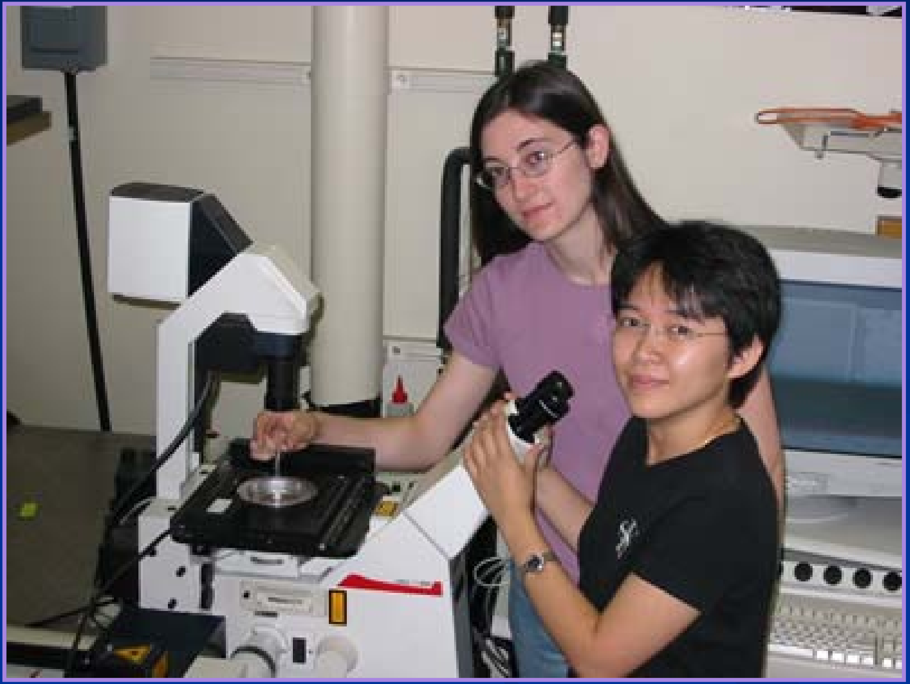
Education

Our research team brings together expertise in colloidal assembly (Lewis), photonics (Braun), and characterization (Bishop) with the common goal of creating 3-D colloidal crystal templates for photonic band gap materials. Together, we advise several graduate students on this project: Angel Chan (PhD/MD), Summer Rhodes (PhD), and Wendy Chan (MS). Both Angel and Summer are NSF Graduate Fellows. In addition, our team has involved several undergraduates to assist in this research project. We have also benefited from close interactions with two Beckman Fellows (post-docs).



Confocal imaging of colloidal crystals (A. Chan and S. Rhodes)